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The Canadian Cixiidae (Homoptera: Fulgoroidea)[1]

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Eleven species of the family Cixiidae have been recorded from Canada (Metcalf, 1936, Gen. Cat. Hemip. 4 (2)). Ten of these are represented in the Canadian National Collection. In addition, ten other species are represented by Canadian specimens. Three of these are previously undescribed. The following are descriptions of the new species, keys to the genera and species known to occur in Canada, and distributional notes on the species from specimens in the collection. External characters are used in the keys. These are not always reliable in determining the males of some closely allied species, because of the frequent absence of dark elytral markings in that sex. The male genitalia show good specific characters, and figures of these are given for the species difficult to determine reliably on external characters.

Representatives of this family do not appear to have been collected intensively in Canada, and there is little doubt that additional species will be found here. Some of the Californian species of *Oliarus* are likely to occur in British Columbia. Species of *Myndus* may have been overlooked in Canada, perhaps because they may be largely subterranean in habits. On the basis of their distributions, it is improbable that any of the known North American species of *Pintalia* or *Psudoliarus* inhabit Canada. The genus *Cixius* is well represented and it is unlikely that any other of the known North American species of this genus will be found in Canada.

Key to Canadian Genera of Cixiidae

1. Posterior tibia with 2 or 3 conspicuous spines 2
   Posterior tibia without spines ..... *Myndus*
2. Mesonotum with 3 carinae; vertex roundly concave at base ..... *Cixius*
   Mesonotum with 5 carinae; vertex angularly excavate at base ..... *Oliarus*

Key to Canadian Species of *Oliarus*

1. Elytra partly or entirely suffused deep brown or blackish 2
   Elytra hyaline, sometimes with darker markings 3
2. Elytron dark smoky brown throughout, stigma and costal margin pale; larger species, 6 mm. or more in length ..... *cinnamomeus* Prov.
   Apical third of elytron suffused brownish, remainder hyaline or relatively so; stigma and costal margin not pale; smaller species, under 6 mm. in length ..... *humilis* (Say)
3. Vertex nearly twice as long as wide (Fig. 8); elytra entirely hyaline, sometimes ochreous-tinged; more slender, smaller species, length 5 mm. or less 4
   Vertex obviously less than twice as long as wide (Figs. 9 and 10); elytra usually with fuscous markings; broader, larger species, over 5 mm. in length 5
4. Lateral carinae of vertex wholly pale. (Western) ..... *franciscanus* (Stal)
   Lateral carinae of vertex each with a pale spot at middle of eye, and with its posterior end pale ..... *ecologus* Caldwell
5. Vertex rounded in front (Fig. 10), brown with pale carinae but without obvious pale spots next the eyes; smaller species, ♂ 5 mm. in length. (Western) ..... *artemisiae* n. sp.

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Vertex obtusely pointed in front (Fig. 9), brown with a pale spot on each side next the eye; larger species, over 6.25 mm. in length. (Eastern) 6

6. Front unicolorous or with only faint light areas on each side of frons next to base of clypeus; smaller species, 6.25 to 7.5 mm. in length ..... *quinquelineata* (Say)

Frons with distinct whitish area on each side next to base of clypeus; larger species, 7.5 to 10 mm. in length ..... *placitus* Van D.

***Oliarus cinnamomeus* Prov.**

Oliarus cinnamomeus Provancher, 1889, Pet. Faune Ent. Can.: 223.

Ontario: Eldorado, in sphagnum bog (G. S. Walley). Provancher described the species from Vancouver.

***Oliarus humilis* (Say)**

Flata humilis Say, 1830, J. Acad. Nat. Sci. Phil. 6: 241.

Quebec: Queen's Park, Aylmer (C. B. Hutchings, A. R. Graham), St. Eustache; Ontario: Gananoque, Pt. Pelee, and Constance Bay (G. S. Walley), Harwich (G. M. Stirrett), Strathroy (H. F. Hudson), Mer Bleue (W. J. Brown, O. Peck), Grand Bend (G. E. Shewell), Vineland (W. L. Putman), Jordan (W. A. Ross), St. Thomas (H. G. D.); Saskatchewan: Estevan (N. Criddle). It has been recorded previously from Ontario.

***Oliarus franciscanus* (Stal)**

Cixius franciscanus Stal, 1859, Freg. Eugenies Resa: 273.

A series of 15 specimens in the Collection appears to be of this species, which has been confused with *O. ecologus* (see below). British Columbia: Seton Lake (J. McDunnough).

***Oliarus ecologus* Caldwell**

Oliarus ecologus Caldwell, 1947, Ohio J. Sci. 47: 76.

In the past this species was misidentified as *O. franciscanus*, which is a western species. *O. ecologus* may be a synonym of *O. complectus* Ball (1902, Can. Ent. 34: 152). *O. franciscanus* is a slightly larger insect than *O. ecologus*, and has the lateral carinae of the vertex wholly pale. The two species are easily distinguished by characters of the male genitalia (Figs. 1, 2, 3, and 6), notably by the shapes of the styles and of the anal appendage. Nova Scotia: Baddeck, swept from *Chamaedaphne* sp. (J. McDunnough); Ontario: Mer Bleue (W. J. Brown, G. S. Walley, F. Ide, R. Ozburn, L. J. Milne).

***Oliarus placitus* Van Duzee**

Oliarus placitus Van Duzee, 1912, Buffalo Soc. Nat. Sci. Bull. 10: 493.

This species is easily distinguished from *O. quinquelineata* by characters of the male genitalia (Figs. 4 and 5). Ontario: Pelee Is. (G. S. Walley).

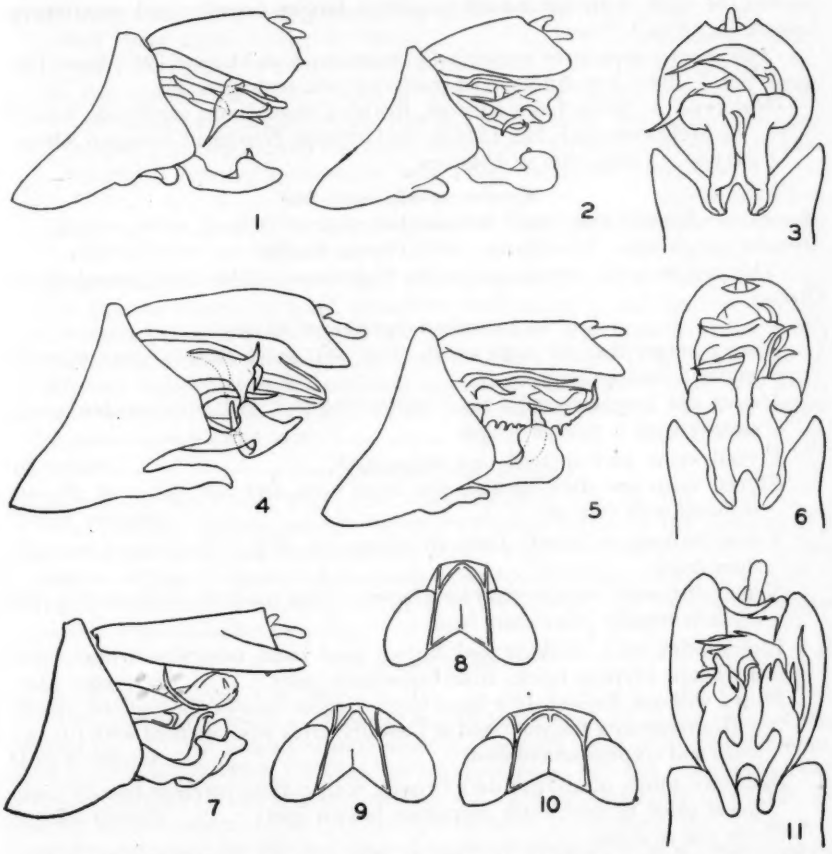
***Oliarus quinquelineata* (Say)**

Flata quinquelineata Say, 1830, J. Acad. Nat. Sci. Phil. 6: 241.

This is a variable species; in some specimens the elytra are almost entirely hyaline, and in other specimens they are variously banded and spotted with fuscous. Nova Scotia: Petite Riviere (J. McDunnough); Quebec: Aylmer (C. H. Curran), Hemmingford (C. E. Petch), Knowlton (L. J. Milne, G. S. Walley); Ontario: Trenton (Evans), Go Home Bay, Lyn, Parry Sound, and Bala (G. S. Walley). It has been recorded previously from Ontario.

***Oliarus artemisiae* n. sp.**

Form and structure of the genus. Vertex (Fig. 6) as long as broad, rounded in front, black with pale carinae. Front black with pale carinae and with a small pale spot at each outer lower angle of the frons. Pronotum black with the carinae broadly pale. Mesonotum black, the posterior margin narrowly



Figs. 1 to 11. *Oliarus* spp. 1. ♂ genitalia, lateral view of *O. franciscanus;* 2. ♂ genitalia, lateral view, of *O. ecologus;* 3. ♂ genitalia, ventral view, of *O. franciscanus;* 4. ♂genitalia, lateral view, of *O. placitus;* 5. ♂ genitalia, lateral view, of *O. quinquelineata;* 6. ♂ genitalia, ventral view, of *O. ecologus;* 7. ♂ genitalia, lateral view, of *O. artemisiae;* 8. Head of *O. ecologus;* 9. Head of *O. quinquelineata;* 10. Head of *O. artemisiae;* 11 ♂ genitalia, ventral view of *O. artemisiae.*

pale. Abdomen and underside of thorax black, the abdominal segments pale-margined laterally. Coxae and femora darkened; tibiae darkened externally, the ridges pale; tarsi pale; tips of tarsal and tibial apical spines black. Elytra milky hyaline; the longitudinal veins yellowish, darkened at their apices, with white bristles and dotted with fuscous; apical cross veins fuscous; three faint fuscous spots in the costal cell; a fuscous suffusion at apex of termen; stigma fuscous, broadly banded with white. Male genitalia (Figs. 7 and 11) asymmetrical, the asymmetry including the styles and the anal appendage; median tooth as long as the pygofers, expanded apically; left style with internal appendage in the form of a long, outwardly curved spine; right style with internal appendage in the form of a flattened, obtusely pointed plate; left side of aedoeagus with a short, broad, flattened projection and a long, slender, upwardly curved spine; right side of aedoeagus with two long, curving spines; dorsal side of aedoeagus with two shorter, curved spines; left side of anal appendage produced posteriorly

beyond the right, with the inward projection longer, broader, and more curved. Length: ♂ 5.0 to 5.25 mm.

This species appears to resemble *O. exoptatus* Van Duzee (1917, Proc. Calif. Acad. Sci. 7: 308), but differs in characters of the male genitalia.

Holotype- ♂, Seton Lake, Lillooet, British Columbia, on sagebrush, June 30, 1926. (J. McDunnough); No. 5876 in the Canadian National Collection, Ottawa.

Paratype- ♂, same data as holotype.

Myndus sordipennis Stal

Myndus sordipennis Stal, 1862, Berliner Ent. Zeit. 6: 308.
Myndus impunctatus Van Duzee, 1890, Psyche 5: 390.

This species is not represented in the Collection. It has been recorded from Ottawa.

Key to Canadian Species of *Cixius*

1. Vertex longer than its basal width (Fig. 14); more slender species; usually under 5 mm. in length 2
   Vertex not longer than its basal width (Figs. 15 and 16); broader species; usually over 5 mm. in length 3
2. Elytral veins dark-spotted, not infuscated ..... *cultus* Ball
   Elytral veins not dark-spotted, the cross veins and the apices of all veins suffused with fuscous ..... *praecox* Van D.
3. Vertex as long as broad, distinctly triangular (Fig. 15); clypeus not paler than frons 4
   Vertex distinctly broader than long, more or less rounded in front (Fig. 16); clypeus usually paler than frons 5
4. Elytra white with black or dark-brown basal band, otherwise without dark markings; clypeus black, frons sometimes paler ..... *stigmata* (Say)
   Elytra without distinct dark basal band, tinged fuscous throughout, usually with a transverse fuscous band at ½ and the cross veins marked with fuscous; frons and clypeus unicolorous ..... *misellus* Van D.
5. Basal two-thirds of elytron dark-brown, with a clear patch at base of costa; apical third hyaline, with numerous brown spots ..... *apicalis* Metcalf
   Elytra not as above 6
6. Frons and clypeus unicolorous, black or dark-brown; elytron usually marked with fuscous, frequently with a basal band, a broken transverse band at ½, and suffused cross veins, and sometimes with a broad band at ⅔ ..... *angustatus* Caldwell
   Clypeus paler than frons 7
7. Elytra tinged fulvous or fuscous throughout 8
   Elytra not tinged fulvous, more or less hyaline, often marked with fuscous 11
8. Larger species, 6 mm. or more in length; elytra almost uniformly deep brown or fuscous 9
   Smaller species, under 6 mm. in length; elytra suffused fulvous 10
9. Veins brown; elytron deep brown with a clear patch at base of costa; costa white, black-spotted; stigma white anteriorly ..... *umbrosus* Walley
   Veins white with dark spots; elytron fuscous, without clear patch at base of costa ..... *meridionalis* n. sp. var.
10. Elytra lighter fulvous, without definite fuscous markings; vertex rounded in front ..... *pini* Fitch
    Elytra darker fulvous, suffused fuscous to a variable extent apically and with a transverse fuscous band at ½; vertex obtusely pointed in front ..... *fulvus* n. sp.

11. Elytra greyish, each with a broad, irregular, brown longitudinal band from base along claval margin to apex ..... *guttulatus* Walley
Elytra without brown longitudinal bands 12

12. Smaller species, not over 5 mm. in length; elytra tinged whitish, without dark basal band, usually with two brown spots in clavus, the posterior forming part of a broken transverse band, the cross veins suffused brownish, sometimes forming a transverse band along the apical cross veins ..... *coloepium* Fitch
Larger species, over 5.75 mm. in length; elytra not tinged whitish, frequently with a brown or blackish basal band 13

13. Elytron usually with distinct black or dark-brown basal band and often with a fuscous transverse band, sometimes broken, at ½, and broken, fuscous transverse bands at the stigma and at the apical cross veins (if these bands are distinct then the dark basal band is always present) ..... *basalis* Van D.
Elytron without distinct dark basal band but with distinct transverse band, sometimes broken, at ½ and broken, irregular transverse bands at stigma and at apical cross veins ..... *meridionalis* n. sp.

Cixius praecox Van Duzee

Cixius praecox Van Duzee, 1925, Proc. Calif. Acad. Sci., 4, 14: 405.

This is readily distinguished from other Canadian species of the genus by the absence of the darker punctation on the elytral veins (see remarks below under *C. cultus*). British Columbia: Armstrong (W. Downes), Kamloops (N. Criddle), Vernon (I. J. Ward), Vernon, on alfalfa (D. G. Gillespie). It has been recorded previously from British Columbia.

Cixius cultus Ball

Cixius cultus Ball, 1902, Can. Ent. 34: 151.

This species resembles *C. praecox* in size and shape and in the form of the vertex (Fig. 14), but is easily distinguished by the dark spots on the elytral veins. Some confusion has arisen between the two species, as Ball did not mention this character directly in his original description. He indicated the character indirectly in that when contrasting the species with *C. stigmata*, which has well marked punctation, he did not give absence of punctation as a distinguishing feature of *C. cultus*. In his key to the species of *Cixius*, Van Duzee (1907, Proc. Acad. Nat. Sci. Phil., 1907: 488) gave "maculation longitudinal" as a character of *C. cultus*. Dozier's key (1928, Miss. Agr. Expt. Sta. Tech. Bull. 14: 70) was adapted from that of Van Duzee and gave the same character. Evidently misled by Ball's description, Metcalf (1923, J. Elisha Mitchell Sci. Soc. 38: 161) gave "veins impunctate" as a distinguishing character in his key; this is a character of *C. praecox*. A further character given by Van Duzee for distinguishing *C. cultus* from *C. praecox* is that in the former species the outer sector of the corium is forked farther from the base than is the inner, whereas in the latter species the two are forked on the same line. Although often reliable, this character varies in both species. There appears to be no significant difference in the male genitalia of the two species. *C. praecox* is apparently confined to regions west of the Rocky Mountains, whereas *C. cultus* is apparently an inhabitant of the prairies. Saskatchewan: Swift Current (A. R. Brooks); Alberta: Brooks, on alfalfa blossom (H. E. Gray), Lethbridge, Stirling, Mountain View, Welling, Raymond, and Magrath (H. L. Seamans).

Cixius stigmata (Say)

Flata stigmata Say, 1825, J. Acad. Nat. Sci. Phil. 4: 336.
Cixius lepidus Van Duzee, 1910, Trans. Am. Ent. Soc. 36: 87.

The whitish elytra with the blackish basal band distinguish the species. Ontario: Pt. Pelee (G. S. Walley), Chatham (W. E. Lindsay). It has been recorded previously from Canada.

***Cixius misellus* Van Duzee**

Cixius stigmatus Van Duzee (*nec* Say), 1906, Can. Ent. 38: 408.
Cixius misellus Van Duzee, 1916, Check List Hemip. Amer.: 79. *Nom. nov.* for *C. stigmatus* Van Duzee.

For many years this species was misidentified as *C. stigmata* (Say), which it resembles in the form of the vertex (Fig. 15). The two species may be distinguished by the characters given in the key, as well as by the male genitalia (figured by Osborn, 1938, Ohio Biol. Surv. Bull. 38: 305). Newfoundland: Mileage 349, on *Picea glauca* (Moench) Voss (Forest Insect Survey); Nova Scotia: Grand R., on *Abies balsamea* (L.) Mill. (C. C. Smith); Quebec: Laniel (H. S. Fleming), Trinity Bay and Mt. Lyall, 1500 ft. (W. J. Brown), Kingsmere (R. N. Chrystal), Kazubazua (G. S. Walley, F. P. Ide). It has been recorded previously from Quebec, Ontario, and British Columbia. Confirmation of the British Columbia record is desirable.

***Cixius basalis* Van Duzee**

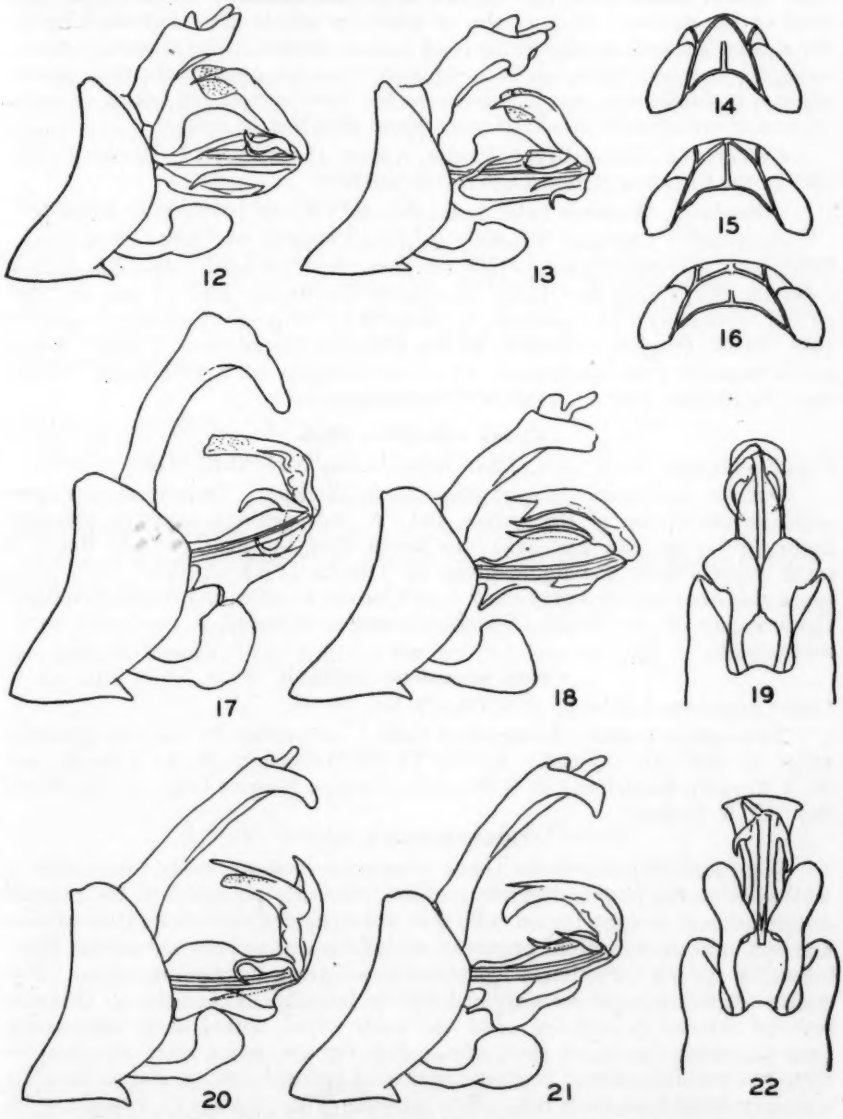
Cixius basalis Van Duzee, 1908, Proc. Acad. Nat. Sci. Phil. 1907: 489.

This is a variable species in the degree of development of the elytral markings and in size. There is also some variation in the male genitalia. In some specimens the spine on the left side of the aedoeagus is curved sharply upward (Fig. 17); in others it is longer, stouter, and nearly straight. Both types of genitalia are represented in series taken in the same locality on the same date. There appear to be no external differences corresponding with the genitalic differences. There is some intergrading between the two types of genitalia. This is a common transcontinental species. Newfoundland: Indian Bay, on *Picea mariana* (Mill.) (Forest Insect Survey), Sandy Lake, on *Abies balsamea* (Forest Insect Survey); Nova Scotia: Baddeck (T. N. Freeman), Kentville (R. P. Gorham); New Brunswick: Bathurst (J. N. Knull); Quebec: Cascapedia R. (C. C. Smith), Knowlton (G. S. Walley, J. A. Adams), Mt. Lyall, 1500 ft. (W. J. Brown), Hull and Wakefield (G. S. Walley), Aylmer; Ontario: Bobcaygeon, Minaki, and Norway Point, Lake of Bays (J. McDunnough), Galetta, Leamington, Jordan, Parry Sound, and Smoky Falls, Mattagami R. (G. S. Walley), Britannia (L. J. Milne), Grand Bend (G. E. Shewell), Trenton (Evans), Burke Falls (F. P. Ide); British Columbia: Agassiz (R. Glendenning), Canim Lake (J. K. Jacob), Seton Lake, Lillooet, on sagebrush (J. McDunnough), Saanich district (W. Downes). It has been recorded previously from Quebec, Ontario, and British Columbia.

***Cixius meridionalis* n. sp.**

Form and structure of the genus. Vertex short, rounded in front, twice as wide at base as its median length, dark-brown with a whitish spot on each side next the eye. Frons dark-brown to black, the carinae yellow or pale brown. Clypeus somewhat tumid, yellow to brown, paler than the frons. Pronotum yellowish or light-brownish. Mesonotum black, the carinae sometimes paler. Thorax blackish beneath. Abdomen black. Coxae and femora blackish; tibiae pale, usually partly suffused blackish; tarsi pale. Elytron greyish hyaline, occasionally suffused brownish; veins white, strongly and closely dotted with fuscous, with black bristles; costa white, dotted and marked with fuscous; stigma fuscous, its anterior third white; a fuscous suffusion at base of each elytron; a broad fuscous band from costa at ⅓ to middle of claval margin, broken and less distinct at the claval suture but unbroken between the costa and the inner sector, two

fuscous costal blotches between it and the stigma; a fuscous suffusion forming an indefinite transverse band at the apical cross veins; some faint fuscous spots in the apical cells. Male genitalia (Figs. 18 and 19) with two long, curving, anteriorly directed spines from aedoeagus; aedoeagus forked at apex; anal appendage relatively short. Length 5.5 to 6.5 mm.



Figs. 12 to 22. *Cixius* spp. 12. ♂ genitalia, lateral view, of *C. coloepium;* 13. ♂ genitalia, lateral view of *C. angustatus;* 14. Head of *C. praecox;* 15. Head of *C. misellus;* 16. Head of *C. basalis;* 17. ♂ genitalia, lateral view, of *C. basalis;* 18. ♂ genitalia, lateral view, of *C. meridionalis;* 19. ♂ genitalia, ventral view, of *C. meridionalis;* 20. ♂ genitalia, lateral view, of *C. pini;* 21. ♂ genitalia, lateral view, of *C. fulvus;* 22. ♂ genitalia, ventral view, of *C. fulvus.*

This species is quite distinct on a basis of characters of the male genitalia. Characteristic features include the shape of the aedoeagus, in lateral view, its two approximately equal-sized spines, and its forked apex. In Metcalf's key (1923, op. cit.: 161) the species runs to *C. basalis*, which it resembles externally but from which it is easily distinguished by the male genitalia (Figs. 17, 18, and 19). It also differs from that species in the less distinctly defined dark basal band on the elytron. In specimens of *basalis* in which other dark markings of the elytron are well developed the basal band is distinct. The transverse elytral band at ½ is usually unbroken in *meridionalis* from the costa to the inner sector, whereas in *basalis* it is usually broken on the outer sector. In lateral view the clypeus of *meridionalis* usually is more tumid than that of *basalis*.

Holotype- ♂, Goose Bay, Labrador, August 16, 1948 (H. C. Friesen). No. 5877 in the Canadian National Collection, Ottawa.

Allotype- ♀, Waskesiu Lake, Saskatchewan, July 26, 1939 (A. R. Brooks).

Paratypes- ♂, Pelissier, Quebec, on spruce, August 21, 1939 (O. Servant); Waskesiu Lake, Saskatchewan, July 26, 1939 (A. R. Brooks) (two specimens); Cameron Bay, Great Bear Lake, Northwest Territories, July 27 and 28, 1937 (T. N. Freeman) (two specimens); Whitehorse, Yukon Territory, August 7, 1948 (M. T. Hughes); Carnaby, British Columbia, September 22, 1939 (Forest Insect Survey) (two specimens); 1 ♀, Fort Wrigley, McKenzie River, Northwest Territories, July 17, 1922 (C. H. Crickmay).

Cixius coloepium Fitch

Cixius coloepium Fitch, 1856, Third Rept. Insects New York: 452.

Ontario: Jordan and Niagara Glen (G. S. Walley). These specimens agree with the description of the species, and the male genitalia resemble Metcalf's figure (1923, op. cit.: Fig. 581). In lateral view the male genitalia differ in some respects from the figure given by Osborn (1938, op. cit.: 305). The species has been recorded previously from Quebec, Ontario, and British Columbia. Confirmation of the British Columbia record is desirable; it may refer to *C. meridionalis*.

Cixius angustatus Caldwell

Cixius angustatus Caldwell, 1938, Ohio J. Sci. 38: 45.

This species is easily distinguished from *C. coloepium* by the male genitalia (Figs. 12 and 13). Quebec: Aylmer (J. McDunnough, H. L. Viereck, and W. J. Brown), Knowlton (G. S. Walley); Ontario: Niagara Glen and Go Home Bay (G. S. Walley).

Cixius fulvus n. sp.

Form and structure of the genus. Vertex very short, about three times as wide as its median length, distinctly carinated, obtusely pointed with the anterior margins almost straight, brown with the carinae lighter and with a pale spot on each side next the eye; frons brown or reddish-brown; clypeus and carinae light-brown or fulvous. Prothorax light-brown to brown; metathorax brown. Abdomen black, the segments margined fulvous laterally. Legs fulvous. Elytron suffused fulvous throughout; costa and veins white, dotted dark fuscous, the veins becoming fuscous at apex; stigma dark fuscous, white anteriorly; base of elytron sometimes suffused fuscous, apical third suffused fuscous, and an irregular transverse band from costa at ½. Male genitalia (Figs. 21 and 22) with the styles rounded, diverging; aedoeagus expanded beneath, left side with a short, curving spine, right side with a longer, curving spine, apex with a prominent spine above; anal appendage rather long, produced at apex to two blunt lateral points. Length 5 to 5.75 mm.

This species runs to *basalis* or *pini* in Metcalf's key (1923, op. cit.: 161). It resembles the latter species in size and form and in the fulvous elytra, but is a much darker insect, with the elytra marked with fuscous. It is quite distinct on a basis of characters of the male genitalia, notably in the shape of the aedoeagus, in lateral view, and of the anal appendage.

Holotype-♂, Cascapedia, Quebec, July 9, 1933 (W. J. Brown). No. 5878 in the Canadian National Collection, Ottawa.

Allotype-♀, Alberton, Prince Edward Island, July 15, 1940 (G. S. Walley).

Paratypes-1 ♂, Alberton, Prince Edward Island, July 15, 1940 (G. S. Walley); 1 ♀, Baddeck, Nova Scotia, July 23, 1936 (T. N. Freeman); 6 ♀, Alberton, Prince Edward Island, July 15, 1940 (G. S. Walley).

***Cixius pini* Fitch**

Cixius pini Fitch, 1851, Cat. Homop.: 45.

This species might be confused with *C. fulvus*, but is easily distinguished by the male genitalia (Fig. 20) and by the characters given in the key. Quebec: Knowlton (L. J. Milne), Cascapedia (W. J. Brown), Rupert House (E. J. LeRoux), Kazubazua and Wolf Lake (G. S. Walley); Ontario: Mer Bleue and Bobcaygeon (G. S. Walley), Ottawa. It has been recorded previously from Quebec and Ontario.

***Cixius umbrosus* Walley**

Cixius umbrosus Walley, 1932, Can. Ent. 64: 22.

Ontario: Burke's Falls (F. P. Ide) (holotype).

***Cixius guttulatus* Walley**

Cixius guttulatus Walley, 1932, Can. Ent. 64: 21.

Quebec: Potton Springs (J. A. Adams) (holotype); Ontario: Prince Edward Co. (Brimley).

***Cixius apicalis* Metcalf**

Cixius apicalis Metcalf, 1923, J. Elisha Mitchell Sci. Soc. 38: 182.

Ontario: Delhi (G. S. Walley).

A New Centipede record for Canada

Mr. John C. Martin, a staff member of the Dominion Parasite Laboratory at Belleville, has recently placed in my hands a centipede, which he collected at Smith Falls, Ontario during the summer of 1949.

There can be no doubt but that it is *Pachymerium tristanicum* Attems, which, to my knowledge, has only been previously known from Vàlazut Transylvania, and the south Atlantic island of Tristan d'Acunha, thereby demonstrating a remarkable distribution.

Heretofore, *Pachymerium*, in the strict sense, had been represented in the northern United States and Canada by a single species, *ferrugineum* (C. L. Koch), which is also common in Europe.—Ralph E. Crabill, Jr., Department of Entomology, Cornell University, Ithaca, New York.

The Varietal Reactions of Cucumbers to DDT and Methoxychlor Dusts[1]

By W. G. MATTHEWMAN[2], D. G. HARCOURT[2], L. M. CASS[2], and W. G. FRIEND[2]

Introduction

Although DDT gives excellent control of the striped cucumber beetle, *Acalymma vittata* (F.), the most serious insect pest of cucumbers in Canada, the technical grade of DDT is generally considered too toxic to cucumbers to be used on that crop with safety. Recently, two related materials that are said to be less toxic to cucurbits in general have been on the market: high-setting-point DDT, and methoxychlor. Carruth and Howe (1948) showed that DDT approaching aerosol grade in setting-point was less injurious to squashes than DDT of technical grade. Several entomologists have reported that cucumbers, like melons and squashes, show definite varietal responses to DDT. Hervey and Schroeder (1946) found the variety Ohio 31 to be more severely injured by DDT than China or Chicago Pickling. Wilson and Sleesman (1947) reported that plants of Ohio 31 were stunted much more by DDT than those of National. This paper is a report on three seasons' investigations of the toxicity of three per cent technical-grade DDT dust to 12 varieties of cucumbers, and one season's investigations of the toxicity of three per cent high-setting-point DDT and methoxychlor dusts to the same 12 varieties.

Scope of the study

In 1947, a commercial three per cent technical-grade DDT dust was applied at Ottawa to plots of 11 table and pickling varieties of cucumbers. Records of foliage injury, dwarfing of the plants, and yield showed that the dust injured all varieties tested, five varieties being particularly susceptible to DDT and six being tolerant. The experiment was repeated in 1948, with a twelfth variety, Arlington Whitespine, added. Whereas there were nine applications of the dust in 1947, there were four and eight applications in 1948, to learn whether, by the end of the season, the plants might overcome the effects of four early applications. In 1949, three per cent dusts of technical grade DDT, high-setting-point DDT, and methoxychlor were applied eight times to the same 12 varieties. The check treatment in all three experiments was a derris dust, one per cent rotenone.

No significant records were obtained on the effects of the dusts on the population of the striped cucumber beetle or the feeding injury, although there was a moderate infestation of that insect in the experimental plots each year at the start of the test. All the plots were dusted with derris, methoxychlor, technical-grade DDT, or high-setting-point DDT; and apparently all four insecticides were effective in controlling the striped cucumber beetle, for the beetles practically disappeared from the plots after the first application. The percentage of plants killed by bacterial wilt each year was negligible.

Materials and Methods

Materials and application

In the 1947 experiment the three per cent technical-grade DDT dust was a commercial product from technical DDT of 89° to 90.5°C setting-point; in 1948 and 1949, from technical DDT of 88°C setting-point. The three per cent high-setting-point DDT dust also was a commercial product, from DDT of 103°C minimum melting-point. The three per cent methoxychlor dust and the derris dust, one per cent rotenone, were prepared in the laboratory, the former from

[1]Contribution No. 2682, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Field Crop Insect Investigations, Division of Entomology, Ottawa.

50 per cent technical methoxychlor wettable powder. The diluent of each of the four insecticides was principally talc.

In 1947 and 1948, the technical-grade DDT dust was applied at an average rate of 30 pounds per acre, and the derris dust at 40 pounds. The rates of application for the four insecticides in 1949 were: technical-grade DDT dust, 40 pounds per acre; high-setting-point DDT dust, 50 pounds; methoxychlor dust, 60 pounds; derris dust, 55 pounds. Less DDT than methoxychlor or derris was required to coat the foliage as the season progressed, for it caused more stunting of the plants. The dusts were applied each year at average intervals of seven days, from July 1 to August 29 in 1947; from July 7 to August 25 in 1948; and from July 6 to August 24 in 1949. All the applications were made with hand dusters: knapsack, bellows dusters when the plants were small; rotary-fan dusters later.

Plot arrangement, and planting

Each year the plots were set out in a factorial, split-plot design of four randomized blocks, each plot containing four hills. There were two plots of each variety in each block in 1947, three in 1948, and four in 1949, one of which in each instance was a check plot, each variety having its separate check. With this arrangement, there were 16 hills of each variety for each insecticide; each hill consisted of three or four cucumber plants, thinned to a single plant shortly after the first application of the dusts. To avoid variables arising from plant competition, the hills were spaced eight feet apart each way in 1947 and six feet apart in 1948 and 1949. There were 88 plots in 1947, forming an experimental area of one-half of an acre; 144 plots in 1948, four-fifths of an acre; 192 plots in 1949, one acre.

The cucumber seed was planted in the field under waxed-paper caps on June 6 in 1947, and on June 1 in 1948; and without the caps on June 28 in 1949. An earlier planting on June 1 in 1949 was destroyed by sunscald because the caps were not removed soon enough in warm weather. The paper caps in 1947 and 1948 may have made the plants tender and particularly susceptible to the first application of DDT, which was made four and nine days respectively after the caps were removed.

Criteria of the phytotoxicity of the dusts

Records of the following were taken each season: (1) foliage injury, (2) lengths of the vines in inches, (3) estimates of plant size in square feet at the end of the season, and (4) number, and weight of fruit in ounces. Seven records of foliage injury were taken at weekly intervals each year, the injury to the foliage as a whole, of each plant, being graded as follows at each inspection:—none, very slight, or slight: Grade 1; medium, severe, or very severe: Grade 2. Tables I and II list the aggregate data of the seven records of foliage injury for each year.

The records of vine length were begun each year after the third application of the insecticides. Being actual measurements of the lengths of the main vines and lateral runners, they were highly accurate, but they could be made only until early August; as the plants grew larger, the measurements became impractical. At the end of the season in 1947 and 1949 estimates were made of the area covered by the plants; these appeared reliable in that they and the yield data corresponded closely. The number and weight of the fruit were recorded every five or six days in August and in September until frost had killed the plants. There were seven such records in 1947, between August 19 and September 23; eight in 1948, between August 10 and September 24; ten in 1949, between August 12 and September 29. On each occasion, the table varieties were stripped of all

TABLE I

INJURY TO FOLIAGE OF CUCUMBERS BY 3 PER CENT TECHNICAL-GRADE DDT DUST, 9 APPLICATIONS IN 1947, 8 APPLICATIONS IN 1948 AND 1949 AT OTTAWA

(Aggregate of 7 records in July and August each year)

Variety	Percentage of plants with Grade 2 foliage injury[1]			
	1947	1948	1949	Mean
Straight Eight	81.3	79.3	80.4	80.3
Midget Bush	89.7	77.3	70.1	79.0
Cubit	64.4	82.8	84.8	77.3
Arlington Whitespine	—	82.0	72.3	77.2
Early Fortune	80.0	56.4	36.6	57.7
A. and C.	27.5	45.3	38.4	37.1
Mean	68.3	70.5	63.8	67.5
Perfection Pickling	23.8	6.3	9.0	13.0
Boston Pickling	12.7	5.0	17.9	11.9
National Pickling	10.6	5.8	10.7	9.0
Delcrow	9.2	4.7	9.0	7.6
Marketer	3.8	6.4	4.0	4.7
Burpee Hybrid	8.3	2.3	2.7	4.4
Mean	11.4	5.1	8.9	8.5

[1]Grade 2: moderate, severe, or very severe.

TABLE II

INJURY TO FOLIAGE OF CUCUMBERS BY 8 APPLICATIONS OF 3 PER CENT TECHNICAL-GRADE DDT, HIGH-SETTING-POINT DDT, AND METHOXYCHLOR DUSTS, 1949, AT OTTAWA

(Aggregate of 7records in July and August)

Variety	Percentage of plants with Grade 2 foliage injury[2]		
	Technical-grade DDT	High-setting-point DDT	Meth-oxychlor
Cubit	84.8	80.4	8.0
Straight Eight	80.4	64.0	6.3
Arlington Whitespine	72.3	61.6	4.0
Midget Bush	70.1	68.8	8.0
A. and C.	38.4	35.7	1.8
Early Fortune	36.6	40.1	4.0
Mean	63.8	58.4	5.4
Boston Pickling	17.9	4.0	3.6
National Pickling	10.7	.9	.0
Perfection Pickling	9.0	.9	2.7
Delcrow	9.0	.9	.9
Marketer	4.0	.0	.0
Burpee Hybrid	2.7	.0	.0
Mean	8.9	1.1	1.2

[2]Grade 2 — moderate, severe or very severe.

cucumbers over four inches in length, and the pickling varieties of those over two inches, until the final record when all the fruit was picked.

Results

Varietal responses of the cucumbers to DDT

Three years' data on foliage injury, stunting of the plants, and yield show that six varieties were tolerant of technical-grade DDT and that six were susceptible; one year's data show that the six varieties susceptible to technical-grade DDT were also susceptible to high-setting-point DDT. The DDT-susceptible varieties were: Straight Eight, Cubit, Midget Bush, Arlington Whitespine, Early Fortune, A. and C.; and the DDT-tolerant varieties were: Delcrow, Perfection Pickling, National Pickling, Marketer, Burpee Hybrid, Boston Pickling.

Foliage injury

The symptoms of foliage injury caused by technical-grade DDT and high-setting-point DDT consisted first of a yellowing of the leaves and later of deformation and curling. All but the very young leaves were affected. The chlorosis usually started at the margin of the leaf, but sometimes toward the centre, as irregular spots varying from bright-yellow to yellowish-green. Gradually the chlorotic areas along the margin widened until the whole leaf except the vein network was yellowish. The veins retained their green colour, standing out darkly against the pale background, this being typical of DDT injury. When severely injured, the leaves lost their normal shape, assuming the outline of basswood leaves, with the apices rounded and sometimes turned to one side. They frequently curled at the margins and in later stages became brittle. Puckering of the leaf surface was noted in two varieties, Arlington Whitespine and Midget Bush. A very slight amount of chlorosis that could be confused with DDT injury occurred in the rotenone-treated check plants, being negligible in all varieties but Midget Bush.

There was no noticeable difference between the foliage injury caused by technical-grade DDT and that caused by high-setting-point DDT, except that the latter was less pronounced in certain varieties. The foliage injury caused by methoxychlor was much less severe, consisting at first of a yellowing of the leaf margin and later of a yellowish mottling of the entire surface. The leaves of plants treated with methoxychlor in 1949 were normal in shape and texture, with no curling.

The foliage injury caused by technical-grade DDT appeared early, being pronounced in some varieties a week after the second application. It was particularly noticeable early in the season in Midget Bush and Cubit. Eight applications caused foliage injury that persisted in most varieties until the end of the season, and, to a lesser extent, so did four applications. One variety, Burpee Hybrid, showed relatively little foliage injury after four applications of technical-grade DDT; another variety, Midget Bush, was so injured by four applications that it did not recover. In most varieties, eight applications caused more foliage injury than four but the increase was more marked in the DDT-susceptible than in the DDT-tolerant varieties.

The difference between the DDT-susceptible and the DDT-tolerant varieties was most evident in the foliage injury data. Table I shows that in six varieties the foliage injury caused by technical-grade DDT was severe, resulting in a mean of 68 per cent Grade 2 injury for the three seasons; in six varieties it was slight, averaging 8.5 per cent Grade 2 injury. In Straight Eight, Midget Bush, Cubit, and Arlington Whitespine, the foliage injury was consistently very severe. Almost as much foliage injury resulted from high-setting-point DDT

TABLE III

STUNTING OF CUCUMBER PLANTS BY 3 PER CENT TECHNICAL-GRADE DDT DUST, 1947-1949, AT OTTAWA

Variety	Average size of plants as a percentage of that of the checks						
	4 applications[3]				8 or 9 applications[4]		
	1947	1948	1949	Mean	1947	1949	Mean
Straight Eight	33.3	78.2	19.8	43.8	12.2	19.6	15.9
Midget Bush	21.7	61.8	50.6	44.7	12.2	48.4	15.9
Cubit	38.5	84.8	19.0	47.4	11.5	21.5	16.5
Early Fortune	42.7	82.8	41.3	55.8	20.9	42.6	31.8
Arlington Whitespine	—	56.6	55.2	55.9	—	34.5	34.5
A. and C	48.9	60.2	24.1	44.4	37.9	39.6	38.8
Mean	37.0	70.7	35.0	48.7	18.9	34.4	25.6
National Pickling	106.0	91.6	72.7	90.1	70.6	52.0	61.3
Marketer	54.4	86.5	59.5	66.8	65.0	63.8	64.4
Perfection Pickling	101.4	73.8	48.8	74.7	90.5	38.8	64.7
Boston Pickling	63.8	129.0	73.8	88.9	60.9	82.2	71.6
Delcrow	99.4	66.5	52.6	72.8	76.8	81.8	79.3
Burpee Hybrid	79.4	75.4	89.7	81.5	89.4	72.3	80.9
Mean	84 1	87.1	66.2	79.1	75.5	65.2	70.4

[3]Plant-size measurements, a week after the fourth application.
[4]Plant-size estimates, a week after the final application.

TABLE IV

STUNTING OF CUCUMBER PLANTS BY 3 PER CENT TECHNICAL-GRADE DDT, HIGH-SETTING-POINT DDT, AND METHOXYCHLOR DUSTS, 1949, AT OTTAWA

Variety	Average size of plants as a percentage of that of the checks					
	4 applications[5]			8 applications[6]		
	Technical-grade DDT	High-setting-point DDT	Methoxy-chlor	Technical-grade DDT	High-setting-point DDT	Methoxy-chlor
Cubit	19.0	39.7	74.9	21.5	41.8	97.5
Straight Eight	19.8	64.5	84.1	19.6	55.7	93.8
A. and C	24.1	90.6	84.0	39.6	67.4	97.2
Early Fortune	41.3	56.9	72.9	42.6	48.9	73.4
Midget Bush	50.6	55.7	228.7	48.4	43.8	129.7
Arlington Whitespine	55.2	101.1	191.9	34.5	53.1	119.5
Mean	35.0	68.1	122.9	34.4	51.7	101.9
Perfection Pickling	48.8	138.5	94.6	38.8	106.6	112.4
Delcrow	52.6	95.4	82.7	81.8	104.1	102.5
Marketer	59.5	148.3	118.8	63.8	99.2	102.4
National Pickling	72.7	141.8	96.9	52.0	84.8	99.2
Boston Pickling	73.8	135.6	144.2	82.2	94.6	115.5
Burpee Hybrid	89.7	175.8	161.0	72.3	108.4	107.1
Mean	66.2	139.2	116.3	65.2	99.6	106.5

[5]Plant-size measurements on August 2, 6 days after the fourth application.
[6]Plant-size estimates on September 1, 8 days after the eighth application.

TABLE V

EFFECTS OF 3 PER CENT TECHNICAL-GRADE DDT DUST ON YIELDS OF CUCUMBERS, 9 APPLICATIONS IN 1947, 8 APPLICATIONS IN 1948 AND 1949, AT OTTAWA

Variety	Yield, in weight[7]			Yield as a percentage of that of the checks			
	1947	1948	1949	1947	1948	1949	Mean
	Ounces	Ounces	Ounces				
Straight Eight	222	347	60	9.5	29.8	5.0	14.9
Cubit	258	399	13	14.3	42.5	1.5	19.5
Midget Bush	39	215	138	3.5	40.3	23.1	22.3
Arlington Whitespine	—	490	209	—	32.5	19.2	25.9
Early Fortune	377	552	316	17.7	43.8	21.2	28.0
A. and C.	1257	799	301	40.5	56.8	22.3	39.9
Mean	431	467	173	17.1	40.9	15.4	24.6
Delcrow	1491	679	227	60.2	80.2	32.8	57.7
Perfection Pickling	2085	1334	331	79.2	78.6	30.3	62.7
National Pickling	1705	930	420	72.8	83.6	38.0	64.8
Marketer	2215	1162	875	67.1	80.4	56.4	68.3
Burpee Hybrid	4167	1592	1047	77.3	94.8	63.9	78.7
Boston Pickling	1527	1033	847	48.0	133.5	70.8	84.1
Mean	2198	1122	625	67.4	91.8	48.7	69.4

[7] Difference required for significance	1948	1949
(P = .05)—	124 ounces	70 ounces
(P = .01)—	165 ounces	93 ounces

as from technical-grade DDT, the same varieties being susceptible or tolerant (Table II). In all varieties tested, the foliage injury caused by methoxychlor was almost negligible.

Stunting of plants

Table III lists three seasons' data on the stunting of plants caused by technical-grade DDT as measured a week after the fourth application, and two seasons' data on the stunting caused by eight or nine applications of technical-grade DDT, as recorded at the end of the season. In the three years, four applications of technical-grade DDT reduced the average size of the DDT-susceptible varieties by 50 per cent, and of the tolerant varieties by 20 per cent. Eight or nine applications caused even more stunting of the susceptible varieties, 75 per cent reduction in size on the average, but no greater stunting of the six tolerant varieties. The data indicate that DDT was more injurious when the plants were young, and suggest that some varieties, particularly Burpee Hybrid, might tolerate technical-grade DDT when the plants were older.

Table IV shows the stunting caused by technical-grade DDT, high-setting-point DDT, and methoxychlor in 1949. High-setting-point DDT caused moderate or severe stunting of the six DDT-susceptible varieties and little or no stunting of the six tolerant varieties. In all varieties it caused definitely less dwarfing than technical-grade DDT. Methoxychlor caused moderate stunting of Early Fortune, Cubit, Straight Eight, and A. and C. and no stunting of the remaining eight varieties.

TABLE VI

EFFECTS OF 4 AND 8 APPLICATIONS OF 3 PER CENT TECHNICAL-GRADE DDT DUST ON YIELDS OF CUCUMBERS, 1948, AT OTTAWA

Variety	4 applications				8 applications			
	Yield[a]		Yield as a percentage of that of the checks		Yield[a]		Yield as a percentage of that of the checks	
	Weight in ounces	Number of fruit	Weight	Number	Weight in ounces	Number of fruit	Weight	Number
Straight Eight	680	140	50.6	56.9	347	68	29.8	27.6
Arlington Whitespine	793	156	52.5	56.9	490	99	32.5	36.1
Midget Bush	204	55	38.1	43.0	215	54	40.3	40.6
Cubit	743	113	79.1	71.1	399	82	42.5	51.5
Early Fortune	706	157	55.1	52.0	552	119	43.8	39.4
A. and C.	864	168	61.4	72.1	799	142	56.8	60.9
Mean	665	132	56.1	58.7	467	94	40.9	42.7
Perfection Pickling	1457	495	85.2	91.5	1334	431	78.6	79.7
Delcrow	657	138	78.4	84.0	679	114	80.0	69.8
Marketer	1291	308	90.1	110.4	1162	258	80.4	92.5
National Pickling	1024	376	92.0	105.0	930	225	83.6	62.8
Burpee Hybrid	1498	245	89.2	94.6	1592	298	94.8	114.3
Boston Pickling	1037	342	134.0	126.2	1033	344	133.5	126.9
Mean	1161	317	94.8	101.9	1122	278	91.8	91.0

[a]Difference required for significance (P = .05)—124 ounces
(P = .01)—165 ounces

Yield

The yield records provide the most significant criterion. Table V shows that eight applications of technical-grade DDT caused a large reduction in the yield of each of the 12 varieties, the average reduction in weight for the three seasons ranging from 16 per cent for Boston Pickling to 85 per cent for Straight Eight. The average reduction in the six DDT-tolerant varieties was 31 per cent; in the DDT-susceptible varieties, 75 per cent. In 1948, the year the cucumbers were least injured by technical-grade DDT, four applications reduced the yield of three common table varieties, Straight Eight, Arlington Whitespine, and Early Fortune, by 50 per cent; eight applications, by 65 per cent (Table VI). On the whole, eight applications caused more injury than four, but the increase was not proportional, again indicating that the cucumbers were more susceptible to DDT when the plants were young. Invariably there was a reduction in the number of fruit produced by the plants as well as in the weight, the two, on the whole, corresponding closely (Table VI).

In 1949, eight applications of technical-grade DDT reduced the yield of each of the 12 varieties very severely. Even such DDT-tolerant varieties as Burpee Hybrid and Boston Pickling yielded only two-thirds as much as the checks; such DDT-susceptible varieties as Straight Eight and Cubit, only one-fifteenth as much. Eight applications of high-setting-point DDT caused a smaller, though still very severe, reduction in the yields of the susceptible varieties but no reduction in the yields of the tolerant varieties except National

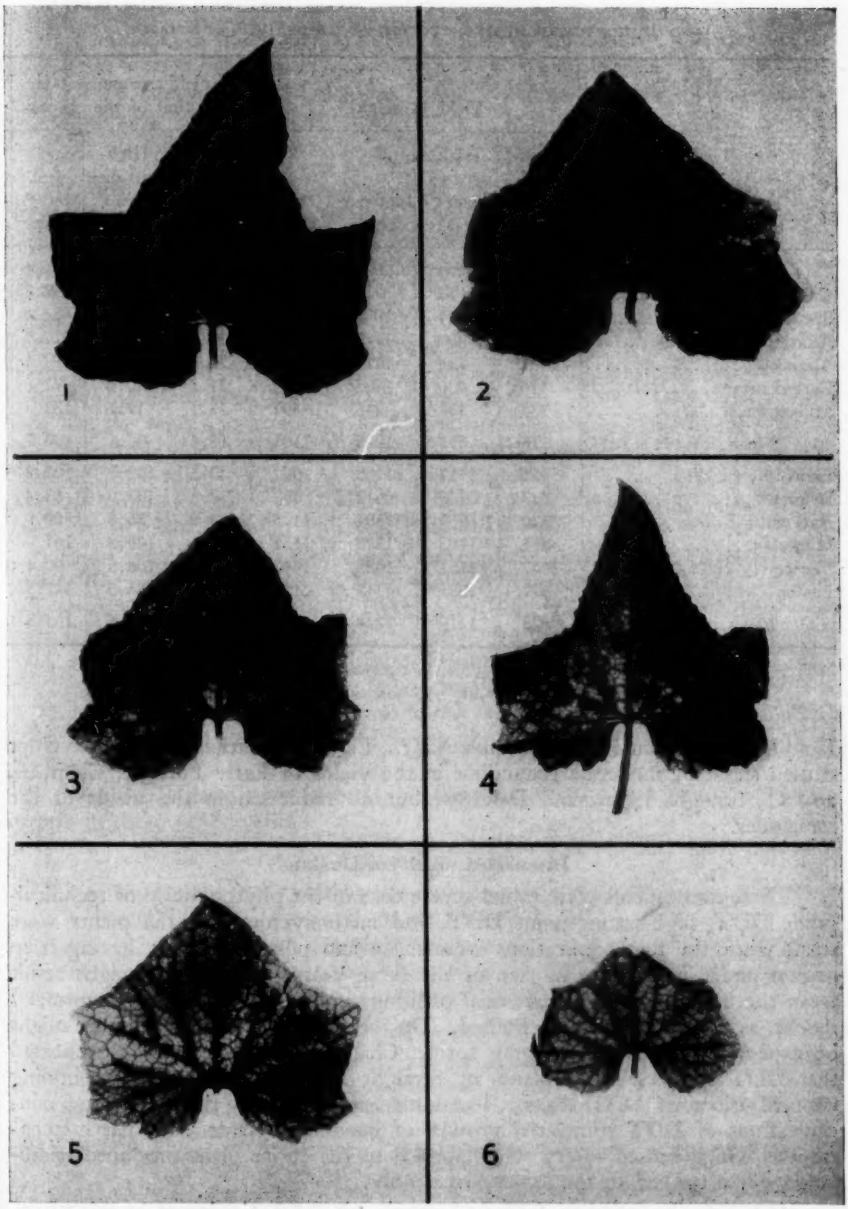


PLATE I. DDT Injury to Foliage of Cucumber, Straight Eight. 1, none; 2, very slight; 3, slight; 4, moderate; 5, severe; 6, very severe. (*Science Service photographs*)

TABLE VII

EFFECTS OF 8 APPLICATIONS OF 3 PER CENT TECHNICAL-GRADE DDT, HIGH-SETTING-POINT DDT, AND METHOXYCHLOR DUSTS ON CUCUMBER YIELDS, 1949, AT OTTAWA

Variety	Yield, in weight[9]				Yield as a percentage of that of the checks		
	Technical-grade DDT	High-setting-point DDT	Methoxychlor	Derris (check)	Technical-grade DDT	High-setting-point DDT	Methoxychlor
	Ounces	Ounces	Ounces	Ounces			
Cubit	13	54	735	894	1.5	6.0	82.2
Straight Eight	60	417	1025	1209	5.0	34.5	84.8
Arlington Whitespine	209	390	1387	1086	19.2	35.9	127.7
A. and C.	301	788	1126	1350	22.3	58.4	83.4
Early Fortune	316	606	1083	1491	21.2	40.6	72.6
Midget Bush	138	102	915	597	23.1	17.1	153.3
Mean	173	393	1045	1105	15.4	32.1	100.7
Perfection Pickling	331	1113	1100	1091	30.3	102.0	100.8
Delcrow	227	720	612	692	32.8	104.0	88.4
National Pickling	420	959	1104	1105	38.0	86.8	99.9
Marketer	875	1703	1580	1551	56.4	109.8	101.9
Burpee Hybrid	1047	1781	1625	1640	63.9	108.6	99.1
Boston Pickling	847	1035	1345	1196	70.8	86.5	112.5
Mean	625	1219	1228	1213	48.7	99.6	101.4

[9]Difference required for significance (P=.05)—70 ounces
(P=.01)—93 ounces

Pickling and Boston Pickling (Table VII). Eight applications of methoxychlor caused slight or moderate reductions in the yields of Early Fortune, Cubit, A. and C., Straight Eight, and Delcrow, but no reduction in the yields of the remainder.

Discussion and Conclusions

These experiments were rather severe tests of the phytotoxicity of technical-grade DDT, high-setting-point DDT, and methoxychlor, for the plants were small when the first applications were made and possibly tender, having been grown under paper caps in two of the three years. Less injury might result from the insecticides in commercial plantings unless the plants were unusually tender, as they might be in a hotbed. On the other hand, greater injury might be expected from DDT in spray form. Chapman and Allen (1948) reported that DDT sprays injured plants of Straight Eight more than corresponding concentrations of DDT dusts. The same authors found that very low concentrations of DDT stimulated growth of cucumber plants, and that concentrations which caused injury when applied to the entire plant produced stimulation when applied to the lower leaves only.

Although six varieties of cucumbers are called DDT-tolerant in this paper, the three years' data show that repeated applications of technical-grade DDT may cause significant injury to even these varieties. High-setting-point DDT appeared considerably less injurious than technical-grade DDT to the six DDT-tolerant varieties in 1949, but only slightly less injurious to the remainder. One

insecticide company has warned against using high-setting-point DDT on Straight Eight, but the 1949 experiment shows that it may be more injurious to Cubit or Midget Bush; in fact, it may injure all the susceptible varieties. It probably might be applied to the tolerant varieties with reasonable safety. Methoxychlor, in the one year it was tested, was considerably less phytotoxic than DDT, but the data indicate that some injury may result from its use on at least five varieties of cucumbers, particularly on young plants.

Summary

In field experiments at Ottawa, three per cent technical-grade DDT dust, setting-point 88° to 90.5°C, and one per cent rotenone (derris) dust as a check treatment, were applied to 12 varieties of cucumbers, nine applications in 1947, four and eight applications in 1948, and eight applications in 1949. In 1949 three per cent dusts of methoxychlor, and high-setting-point DDT (minimum melting-point, 103°C), were added to the study. Three years' data on foliage injury, stunting of the plants, and yield showed that although all varieties tested were moderately or severely injured by technical-grade DDT, six varieties were consistently susceptible, whereas six were tolerant. One year's data showed that the six varieties susceptible to technical-grade DDT were also susceptible to high-setting-point DDT. The varieties susceptible to DDT were: Straight Eight, Cubit, Midget Bush, Arlington Whitespine, Early Fortune, A. and C.; and the varieties tolerant of DDT were: Delcrow, Perfection Pickling, National Pickling, Marketer, Boston Pickling, Burpee Hybrid.

Eight applications of DDT caused more injury than four, particularly to the susceptible varieties, but the increase was not proportional, indicating that the plants were more susceptible to DDT when young. DDT reduced not only the weight but also the number of fruit, the two corresponding closely. High-setting-point DDT caused considerably less injury than technical-grade DDT to the six tolerant varieties, but only slightly less injury to the remainder. Although methoxychlor, in the one year it was tested, was less injurious than either grade of DDT, eight applications caused slight or moderate reductions in the yields of five varieties.

Each of the four insecticides gave adequate control of the striped cucumber beetle in these experiments.

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Preliminary Observations on the Control of Grasshoppers and Related Insects on Flue-cured Tobacco with Chlordane Dust Applied to the Field Margins[1]

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Grasshoppers, tree crickets, and katydids always cause some injury to tobacco in southwestern Ontario, and at times the injury is very severe. The leaves may be riddled or even completely stripped, the most severe injury usually occurring late in the season, about harvest time. These insects breed in sod, in wood-lots, and along roadsides, and such areas require special attention when control measures are undertaken. Because it is usually considered advisable to restrict the amount of insecticide applied to tobacco leaves, the chlordane dust used in this experiment was applied only to the vegetation bordering the field. Any control by applying poison to tobacco plants can be effected only after at least limited feeding and some injury to the leaves; but treatment of field margins uses waste plants as the poison 'carriers' and a large part of the injury to tobacco is avoided. This method of control is useful only for insects which feed on general vegetation and would be of little value in controlling species which restrict their feeding to the cultivated crop.

Methods.—In the spring of 1949, a 1.3-acre field of flue-cured tobacco at the Dominion Experimental Station, Delhi, Ont., was made available for experimental purposes. The field was located in the Fox sand typical of the tobacco-growing area, and was bordered on three sides by headlands and roadside and on the fourth side by a field of oats. It was stipulated that the tobacco in this field was not to be treated with any insecticides.

Five per cent chlordane dust was applied at 22 pounds per acre by means of a rotary hand duster in the early morning of June 22. One headland (140 ft. x 47 ft.) and almost half the length of the roadside (310 ft. x 20 ft.) were treated. These border areas consisted of old sod, with widely separated deciduous and coniferous trees.

The amount of injury was recorded by counting the feeding apertures on 250 plants, in blocks of 25 plants each, in the check and protected areas, respectively. The same plants were examined throughout the season by the same person.

Three categories were used to indicate the degree of injury, as follows: one to five feeding apertures per plant were considered slight injury; six to 15, moderate; and over 15, severe.

A pre-treatment record of the injury was taken on June 21. Subsequent post-treatment records were taken on July 1, 13, and 28 and August 12 and 22. Normal priming operations rendered further recordings unpractical.

Results.—Table I indicates that the dust treatment gave an appreciable degree of protection to the tobacco for over two months. The percentage of plants injured severely is the most important category, since some of the normally valuable leaves on these plants were so riddled as to be worthless. It is in this 'severe' category that the protective effect of the treatment is most apparent. The 'total' column indicates that nearly 100 per cent of the plants in the check area were injured, whereas the number of plants showing injury in the protected area in no case exceeded 66.8 per cent.

Discussion and Conclusions.—Under the conditions of this experiment, the treatment of borders of an infested field with five per cent chlordane dust appar-

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TABLE I.

RESULTS OF DUSTING FIELD BORDERS ON JUNE 22 WITH 5 PER CENT CHLORDANE AT 22 POUNDS PER ACRE FOR THE CONTROL OF ORTHOPTEROUS PESTS OF TOBACCO, DOMINION EXPERIMENTAL STATION, DELHI, ONT., 1949.

Date recorded (500 plants examined each date)	Percentage of Plants Injured							
	Protected Area				Check Area			
	1 Severely	2 Moderately	3 Slightly	Total	Severely	Moderately	Slightly	Total
June 21..... (pre-treatment)	0.4	6.8	36.4	43.6	0.4	10.4	30.0	40.8
July 1.....	2.0	11.2	37.6	50.8	4.8	12.0	43.6	60.4
July 13.....	4.4	12.0	38.0	54.4	34.0	26.8	29.2	90.0
July 28.....	5.2	8.8	42.4	56.4	58.4	22.4	14.0	94.8
Aug. 12.....	8.4	8.4	50.0	66.8	62.0	17.2	19.6	98.8
Aug. 22.....	11.6	10.0	42.0	63.6	57.6	21.6	18.0	97.2

1. Over 15 feeding apertures per plant.
2. 6 to 15 feeding apertures per plant.
3. 1 to 5 feeding apertures per plant.

ently gave good protection. It is doubtful whether the single application gave commercial control after July 28; nevertheless, subsequent records indicated that an important and prolonged degree of protection was obtained. Possibly a second application, four or five weeks after the first, would have provided satisfactory control.

The results may also indicate that the movement of grasshoppers within and into the field was not extensive.

In conclusion, it may be said that control of grasshoppers by treating field borders with five per cent chlordane dust has many obvious advantages and apparently gives an important degree of protection to flue-cured tobacco.

The Leafhopper *Typhlocyba froggatti* Baker as an Apple Pest in Ontario

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A large apple orchard at Queenston, Ont., was sprayed regularly with DDT in 1946, 1947, and 1948, but in 1949 part of it was left unsprayed. The unsprayed trees became so heavily infested with leafhoppers that by the end of August the foliage was severely injured. The injury was similar to that caused by the white apple leafhopper, *Typhlocyba pomaria* McAtee.

A collection of more than 200 nymphs was made on August 11 and reared to maturity, and additional adults were collected on August 29. All of the males, except a few specimens of *Erythroneura lawsoniana* Baker, proved to be *Typhlocyba froggatti* Baker.

This species, which has passed under the specific names *australis* Froggatt, *xanthippe* McAtee, *malini* Delong, and *oxyacanthae* Ribaut, was originally described from Australia; in that continent and New Zealand it has long been a serious pest on apple. It also occurs in Great Britain and France. In North America it has been recorded from Massachusetts, New York, and Ohio and has been of some economic importance in the latter state. During 1948 and 1949 the author found it breeding in small numbers on apple, plum, sweet and sour cherries, and eastern choke cherry, *Prunus virginiana* L., in the Niagara Peninsula. The infestation at Queenston is apparently the first known to cause serious injury in Ontario.

T. froggatti is usually a deeper yellow than *T. pomaria* but can be distinguished with certainty from the latter only by the male genitalia, which are figured by McAtee (*Proc. U.S. Nat. Mus. 68:* 1-47) under the synonym *xanthippe*. The life-history has not been studied locally but appears to be similar to that of *pomaria*.

It would be of interest to know the extent to which *froggatti* is replacing *pomaria* in Ontario, and whether greater resistance to DDT is causing an increase of the former species.

Radioisotopes in Entomology

An article with the above title, recently published by D. W. Jenkins and C. C. Hassett, in the magazine *Nucleonics* (McGraw-Hill Publishing Co., Inc., 330 W. 42nd St., New York, 18, N.Y.) has been passed to us by the Dominion Entomologist with the suggestion that it might be of interest to the readers of the *Canadian Entomologist*.

Many of the major advances in science are due to the combination of disciplines or techniques that had hitherto been independent. The most important example is perhaps the fusion of mathematics and physics, which after a long development, appears full-fledged in the work of Galileo. The essential feature in mathematical physics as a new branch of science was of course the interpretation of exact measurements of material properties in terms of laws of the mathematical order. From this cross-fertilisation there developed the immense structure of modern exact science. In a different field, the application by Lavoisier, of quantitative methods to the transformations of matter, founded the science of chemistry. The use of radioisotopes in entomology is another example of these fruitful combinations, less important certainly than those we have mentioned but of considerable interest.

The word *isotope* in its original meaning, referred to elements which occupy the same place in the table of Mendeleef, because they have the same properties, but differ in their atomic weights. The existence of isotopes was first demonstrated by J. J. Thomson in the case of neon. Later Aston showed that chlorine, like neon, is a mixture of two elements. These have atomic weights of 35 and 37 but they occur in such proportions that the atomic weight of the mixture is 35.46—a figure both puzzling and difficult to keep in mind as those who studied chemistry from the pre-electronic textbooks will remember.

Radioisotopes are elements having the same chemical properties but differing in respect to the radiations they emit as a result of atomic disintegration. The type of radiation may differ though the atomic weight is the same. As is well known a large number of radioactive isotopes can now be prepared artificially.

The value of radioisotopes in entomology depends primarily on the fact that they do not occur naturally in insects and can be detected by appropriate instruments if they are introduced into the body; and secondarily on the fact that since they have the same chemical properties as the non-radioactive elements, they behave in the organism, in the same way.

In human beings, ordinary iodine tends to accumulate in thyroid; so also does radioactive iodine. In insects, iodine accumulates in the cuticle and this is true of the radioisotope of iodine. Barium accumulates in the gut, Malpighian tubes and fat body, but is not found in the nervous system. By the use of radioisotopes and suitable techniques the distribution of radioactive substances can be accurately determined. This obviously opens up interesting fields of physiological investigation.

Another important development made possible by radioisotopes, is the identification of individual insects from a particular source, such as a pond, a plant, or a patch of soil. Since the radiations can be detected, even through layers of animal or plant tissue or in the depth of the earth, the movements of insects can be followed with an accuracy hitherto unobtainable; migrants from a distant point can be recognized; and feeding habits and parasitic relations can be demonstrated.

Canadian entomologists are already engaged in investigations entailing the use of radioisotopes and some of their published work is mentioned by the authors of the article cited above. The use of radioactive materials, as is well known, requires special apparatus and is not without danger so that definite precautions must be taken. It is not a field for the inexperienced amateur. However in proper hands the new technique will certainly be fruitful.

W. R. THOMPSON.

Book Review

***The Mayflies of Florida*—by Dr. Lewis Berner. The University of Florida Press, Gainesville, Fla., Volume IV, Number 4 Biological Science Series, University of Florida studies. With 267 pages of text there are 19 distributional maps, 88 text figures, 24 full page half-tone illustrations, 5 pages of bibliography and a full index. Price of paper-bound copy $5.50.**

This well designed paper setting forth Dr. Berner's research on mayflies of the Florida region should have appeal not only to specialists in this group of insects and to zoologists of Florida but, because of its broad treatment particularly from the zoogeographical viewpoint, to a large group which up till now has not had access to much data on these insects from this unique North American

region. The paper shows a finish which reflects the author's maturity in the field some of this being no doubt a result of the fact that publication of the paper, prepared as a doctorate thesis in 1941, has not been possible until this year.

From 1941 to 1946 the author was on active service with the U.S. Sanitary Corps and had experience in the East Indies until placed on the inactive list as a Lieutenant Colonel in 1946.

There is a brief historical account of recent work on mayflies by North American workers, followed by general accounts of the characteristics of the order, relationships of groups within it and the evaluation of taxonomic characters. Comparison of the Florida fauna with northern faunae is treated with a discussion of habits of the insects and zoogeography. The climate and particularly the habitats represented in Florida are described at length. Keys to both imagos and nymphs are included with figures illustrating diagnostic features conveniently placed adjacent to the text. The annotated list of genera and species which follows contains much original observational material on the habits and habitats and extensive lists of date and locality records. The illustrations are well done and the full-page half-tone reproductions by Miss Esther Coogle, staff artist at the University of Florida, greatly enhance the value of the paper.

The apparent lack of definite seasonal phenomena in the life cycles of many species in Florida in contrast to the conditions obtaining further north for the same species is brought out.The paucity of species in this state as compared with their greater numbers in continental regions is correlated with the uniformity of aquatic habitats encountered and particularly associated with the absence of piedmont terrain.

Many further problems are suggested and this paper should stimulate similar undertakings in other parts of the continent.

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